Production Method of Multi-layer Information Record Carriers

Field of the Invention

The invention relates to a production method of multi-layer information record carriers, and more particularly, to a production method of manufacturing multi-layer information record carriers by replacing a substrate that comprises a signal duplication layer with a metallic stamping plate.

Background of the Invention

Along with the advent of the information and multimedia era, there is an increasing need for greater record density and capacity of record carriers by 3C products – computers, communications, and consumer electronics. The record density of the optical information record carrier that uses a red laser as the light source for reading information is relatively restricted because of an optical diffraction limit. So far, certain principles and methods of increasing the record density of optical information record carriers have been introduced. The more important ones for which the technology for the manufacturing processes have recently been developed include: a reduction of the wavelength of the laser light source for reading, such as by replacing the red laser with a blue laser as the light source for reading, or increasing the caliber of a lens. Additionally, improvements may be made in the method of encoding digital signals or using the so-called super-resolution near-field optical structured DVD recording. The record density can be effectively increased by means of the above methods.

Another technology for increasing the record capacity of an information record carrier (such as DVD) involves providing multiple layers for the information record carrier. In other words,

the technology creates a 3-D multi-layer record carrier, multiplying its record capacity. The current methods for manufacturing multi-layer information record carriers include the method disclosed in US patent no.5059473 – injection molding, by which a central substrate is created by injection and signals are formed on both sides of the substrate. A signal duplication layer is then put on both sides of the substrate by means of plating, and eventually a protective plate is affixed to the substrate with transparent glue. Another method is called surface transfer. Given the low adhesive affinity between Polycyclohexylethylene (PECH) and Aluminum, the method of surface transfer involves plating a metallic layer (for example, Aluminum layer) that acts as a total reflection layer on a substrate made from Polycyclohexylethylene by means of high-pressure injection molding.Affixing, with optical glue, the Polycyclohexylethylene substrate to another substrate that is full of signals and is plated with a semi-reflection layer, then the optical glue is subjected to curing through the ultra violet light, and finally when the two substrates are separated from each other. Due to the low adhesive affinity between Polycyclohexylethylene (PECH) and Aluminum, the Aluminum layer is separated from the PECH substrate and then it is affixed to another substrate, becoming a single-side dual-layer DVD. A dual-side dual-layer digital video disc, DVD, is formed when two single-side dual-layer substrates with a thickness of 0.6mm are affixed to each other through their total reflection layers. Both of the two aforesaid methods may produce a multi-layer information record carrier at a single-side dual-layer level or any higher level. However, both methods employ a high-pressure manufacturing process, thus their defective rates remain high.

In addition, there are some other methods for manufacturing single-side dual-layer record carriers. Firstly, in US patent no.5171392, a reflective layer is plated on a substrate for which a signal layer has been cast in advance. It is then affixed to a stamping plate by means

of resin. The stamping plate is then detached from the substrate and the second record layer is formed. Finally, the second reflective layer is plated on the substrate and a protective layer is added onto the substrate. Similarly, in US patent no.5708652, a reflective layer is also plated on a substrate for which a signal layer has been cast in advance, but a high molecular layer is placed in between the substrate and the stamping plate. The high molecular elements are then melted down at a high temperature and a high pressure and they flow into the grooves of the stamping plate. The melted elements are solidified by ultra violet light. Finally, the stamping plate is detached. The aforesaid methods employ a relatively expensive metallic stamping plate. Take US patent no.5874132 as an example. Its manufacturing process primarily involves plating a reflective layer and the first record layer on a substrate beforehand, and pouring high molecular resin while turning a roller-shaped stamping plate. The second record layer is formed provided that their relative speeds are well controlled. As regards this method, attention should be paid to the position of the substrate relative to the stamping plate as well as applying forces to the substrate evenly. Another shortcoming of the method is that it is difficult to produce roller-shaped stamping plates.

In short, all of the above methods require a metallic stamping plate with the exception of surface transfer. However, a PECH stamping plate may not be recycled, making it impossible to cut manufacturing costs. As for the production of multi-layer information record carriers, both surface transfer and injection molding can produce multi-layer information record carriers at a single-side dual-layer lever or higher, though both of them involve a high-pressure manufacturing process, thus their defective rates remain high. US patents no.5171392, no.5708652 and no.5874132 can only produce single-side dual-layer record carriers.

Object and Summary of the Invention

In view of this, the object of the invention is to use a method, which is suitable for mass production, to manufacture multi-layer information record carriers. The production method for multi-layer information record carriers mentioned in the invention involves forming a signal duplication layer on a substrate that contains signals. The substrate that comprises the signal duplication layer replaces a metallic stamping plate for generating a signal layer, thus the manufacturing cost of multi-layer information record carriers is reduced. In addition, the simple, speedy manufacturing process facilitates the creation of automation facilities for mass production and the enhanced production of good products.

The first method of the invention involves forming a signal duplication layer on a substrate that contains signals, so that it becomes the stamping plate for the signal duplication layer. Then the signal duplication layer is coated with a solution of high molecular resin. Illumination with ultra violet light causes the resin to cure and the signal duplication layer is turned into a signal layer. The signal layer is coated with another layer of high molecular resin solution and is thus turned into a holding layer in order to hold a second substrate that contains signals and comprises a semi-reflection layer. Again, illumination with ultra violet light causes the curing of the holding layer so as to glue the second substrate and the signal layer together. Since the adhesive force between the signal layer and the signal duplication layer of a high molecular material is smaller than that between the signal layer and the holding layer of the second substrate, the signal layer and the signal duplication layer are separated from each other. A total reflection layer is plated on the signal layer so as to form a single-side dual-layer information record carrier. Or, a semi-reflection layer is plated on the signal layer, the single-side dual layer information record carrier is treated as a substrate, and

the aforesaid procedure is repeated. Both the signal duplication layer that acts as a stamping plate and the substrate can be recycled repeatedly. The method produces multi-layer information record carriers at a single-side triple-layer level or higher.

The second method of the invention involves forming a signal duplication layer on a substrate that contains signals. A solution of high molecular resin is then smeared and spread over the signal duplication layer, and the signal duplication layer is turned into a signal layer. Directly affix it to the second substrate that contains signals and comprises a semi-reflection layer. Illumination with ultra violet light causes curing of the signal layer. Glue the second substrate and the signal layer together, and detach the signal duplication layer from the signal layer. The signal layer is plated with a total reflection layer so as to create a single-side dual-layer information record carrier. Or, a semi-reflection layer is plated on the signal layer, the single-side dual layer information record carrier is treated as a substrate, the aforesaid procedure is repeated, and multi-layer information record carriers are produced at a single-side triple-layer level or higher. In the second method, a single layer of high molecular solution is used as a signal layer and a holding layer simultaneously. To enable the smooth detachment of the signal duplication layer from the signal layer, different materials are employed to form the signal duplication layer and the semi-reflection layer. Different materials adhere to the signal layer under different degrees of adhesive force. The adhesive force between the signal layer and the signal duplication layer must be smaller than that between the signal duplication layer and semi-reflection layer, in order to allow the signal layer and the signal duplication layer to be separated from each other.

Detailed Description of the Preferred Embodiment

As regards the production method of multi-layer information record carriers of the invention, the manufacturing process of the first embodiment is shown in Figures 1A-1H. It includes the following steps: a first substrate 104 (as shown in Figure 1A) that contains signals is provided. A signal duplication layer with a thickness of 5-60nm is plated on the first substrate 104 (as shown in Figure 1B). By means of spin coating, the signal duplication layer 102 is coated with a layer of high molecular resin solution and thus the signal duplication layer 102 is turned into a signal layer 114. The thickness of the signal layer 114 is kept between 40 and 65 μm (as shown in Figure 1C). Illumination with ultra violet light 106 causes the curing of the signal layer (as shown in Figure 1D). The coating of another layer of high molecular resin solution generates a holding layer 108 that is then affixed to a second substrate 112 that contains signals and comprises a reflective layer 110 (as shown in Figure 1E). Illumination with ultra violet light 106 causes the curing of the holding layer 108 (as shown in Figure 1F). Since the adhesive force between the signal layer 114 and the signal duplication layer 102 is smaller than that between the signal layer 114 and the holding layer 108, the signal layer 114 is detached from the signal duplication layer 102 (as shown in Figure 1G). The signal layer 114 is coated with a total reflection layer 116 to form a single-side dual-layer information record carrier 100 (as shown in Figure 1H). The first embodiment of the invention may be used to produce DVD of various specifications. As shown in Figures 2A-2F, which depict the manufacturing processes of DVDs of various specifications by making reference to the first embodiment of the invention, affixing the single-side dual-layer information record carrier 100 to a plastic substrate 118 that does not contain any signal (as shown in Figure 2A) generates a DVD9 120 (as shown in Figure 2B). Affixing the single-side dual-layer information record carrier 100 to a plastic substrate 122 that comprises a layer of signals (as shown in Figure 2C) generates a DVD14 130 (as shown in Figure 2D).

Affixing two single-side dual-layer information record carriers 100 to each other with their total reflection layers touching each other face to face (as shown in Figure 2E) generates a dual-side dual-layer read-only DVD18 140 (as shown in Figure 2F).

As shown in Figures 3A-3J, which depict the manufacturing process of the second embodiment of the invention, a first substrate 204 (as shown in Figure 3A) is coated with a signal duplication layer 202 with a thickness between 5 and 60nm (as shown in Figure 3B). By means of spin coating, the signal duplication layer 202 is coated with a high molecular resin solution that forms a signal layer 214 (as shown in Figure 3C). The thickness of the signal layer 214 is kept between 40 and 65 μm. Illumination with ultra violet light 106 causes the curing of the signal layer 214 (as shown in Figure 3D). The coating of another layer of high molecular resin solution generates a holding layer 208. The holding layer 208 is affixed to a second substrate 212 that contains signals and is plated with a reflective layer 210 (as shown in Figure 3E). Illumination with ultra violet light causes the curing of the holding layer 208 (as shown in Figure 3F). Since the adhesive force between the signal layer 214 and the signal duplication layer 202 is smaller than that between the signal layer 214 and the holding layer 208, the signal layer 214 is detached from the signal duplication layer 202 (as shown in Figure 3G), forming a single-side dual-layer information record carrier 200 (as shown in Figure 3H). Treat the single-side dual-layer information record carrier as the second substrate, coat the second substrate with a semi-reflection layer, repeat the steps of the second embodiment, and form a single-side triple-layer information record carrier 220 (as shown in Figure 3I). Similarly, with the same method, it is possible to produce a single-side quadri-layer information record carrier 230 (as shown in Figure 3J) as well as a multi-layer information record carrier with more than four layers.

As shown in Figures 4A-4F, which depict the manufacturing process of the third embodiment of the invention, a first substrate 304 (as shown in Figure 4A) that contains signals is coated with a signal duplication layer 302 with a thickness between 5 and 60nm (as shown in Figure 4B). By means of spin coating, the signal duplication layer 302 is coated with high molecular resin solution and forms a signal layer 308. Then, it is affixed to a second substrate 312 that contains signals and comprises a reflective layer 310 (as shown in Figure 4C). Illumination with ultra violet light causes the curing of the signal layer 308, and it is then affixed to the second substrate 312 (as shown in Figure 4D). Since the adhesive force between the signal layer 308 and the signal duplication layer 302 is smaller than that between the signal layer 308 and the reflective layer 310 of the second substrate 312, the signal layer 308 is detached from the signal duplication layer 302 (as shown in Figure 4E), forming a single-side dual-layer information record carrier 300 (as shown in Figure 4F) after plating the signal layer 308 with a total reflection layer 306.

As shown in Figures 5A-5F, which depict the manufacturing processes of DVDs with different specifications described in the third embodiment of the invention, affixing the single-side dual-layer information record carrier 300 to a plastic substrate 318 that does not contain any signal (as shown in Figure 5A) generates a DVD9 320 (as shown in Figure 5B). Affixing the single-side dual-layer information record carrier 300 to a plastic substrate 322 that comprises a layer of signals (as shown in Figure 5C) generates a DVD14 330. Affixing two single-side dual-layer information record carriers 300 to each other with their total reflection layers touching each other face to face (as shown in Figure 5E) generates a dual-side dual-layer read-only DVD18 340 (as shown in Figure 5F).

As shown in Figures 6A-6H, which depict the manufacturing process of the fourth embodiment of the invention, a first substrate 404 (as shown in Figure 6A) that contains signals is coated with a signal duplication layer 402 with a thickness between 5 and 60nm (as shown in Figure 6B). By means of spin coating, the signal duplication layer 402 is coated with high molecular resin solution that forms a signal layer 408. Then, it is affixed to a second substrate 412 that contains signals and comprises a reflective layer 410 (as shown in Figure 6C). Illumination with ultra violet light causes the curing of the signal layer 408. It is then affixed to the second substrate 412 (as shown in Figure 6D). Since the adhesive force between the signal layer 408 and the signal duplication layer 402 is smaller than that between the signal layer 408 and the reflective layer 410 of the second substrate 412, the signal layer 408 is detached from the signal duplication layer 402 (as shown in Figure 6E), forming a single-side dual-layer information record carrier 400 (as shown in Figure 6F) after plating the signal layer 408 with a total reflection layer 406. Treat the single-side dual-layer information record carrier 400 as the second substrate, repeat the steps of the third embodiment, and form a single-side triple-layer information record carrier 420 (as shown in Figure 6G). Similarly, by repeating the steps of the third embodiment, it is possible to produce a single-side quadri-layer information record carrier 430 (as shown in Figure 6H) as well as a multi-layer information record carrier with more than four layers.

As regards the production method of multi-layer information record carriers disclosed in the invention, the materials chosen for the first, second, third and fourth embodiments are as follows: Polycarbonate, PMMA or glass (select any option as appropriate). There are three options for producing the high molecular resin solution for the record layer, namely Epoxy, acrylic or Polyester (choose one of them). Choose one of the following for plating a signal duplication

layer on the substrate that contains signals: gold, silver, aluminum, chromium, platinum, nickel, silicon or their alloys. Choose one of the following for the semi-reflection layer placed in between the signal layer and the signal duplication layer: gold, silver, aluminum, silicon or their alloys. Choose one of the following for producing the total reflection layer: gold, silver, aluminum, chromium, copper, silicon or their alloys.

As regards the production method of multi-layer information record carriers disclosed in the invention, the thickness of the record layers in the first, second, third and fourth embodiments is controlled by the speed of spin coating and the concentration of the high molecular resin solution. Coats have different thickness to meet the different requirements of the specifications of the DVDs. In the embodiments, the first substrate and the second substrate are 1.2mm and 0.6mm respectively, and corresponding to different wavelengths of the laser, their thickness can be one of the following: 1.1mm, 0.5mm and 0.3mm. After being detached from a signal layer, the first substrate that is used to copy a signal layer can be recycled up to 30 times in copying the next signal layer, requiring no special treatment. The high molecular resin solution for producing the record layer is made from photopolymer. The record layer is subjected to rapid curing by exposure to ultra violet light, requiring no air drying of the solvent of the high molecular resin solution of the record layer or drying the record layer by heat. The manufacturing process is thus streamlined and a lot of manufacturing time is saved

Description of the Drawings

Figures 1A-1H show the manufacturing process of the first embodiment of the invention.

Figures 2A-2F depict the manufacturing processes of DVDs of various specifications with reference to the first embodiment of the invention.

Figures 3A-3J show the manufacturing process of the second embodiment of the invention.

Figures 4A-4F show the manufacturing process of the third embodiment of the invention.

Figures 5A-5F depict the manufacturing processes of DVDs of various specifications with reference to the third embodiment of the invention.

Figures 6A-6H show the manufacturing process of the fourth embodiment of the invention.